How Much We Lose in Sky Localisation If We Neglect Spin Effects in NS-NS and NS-BH Binaries

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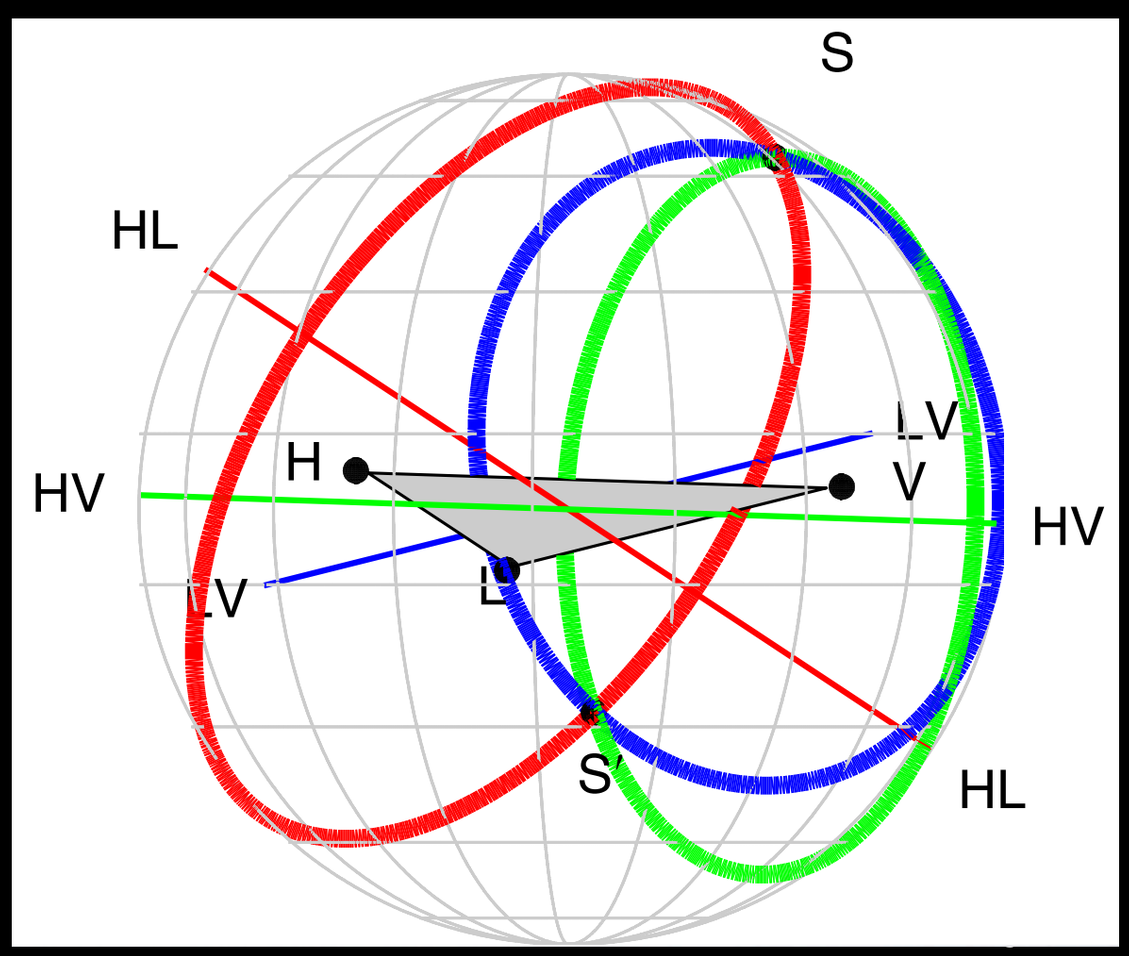
Astrophysical population

- Masses of Neutron-Star <3 $M_\odot$, fiducial ~1.4 $M_\odot$
- Spins:
  - Fastest spin from EOS: a<0.7 (Lo et al., arXiv:1011.3563)
  - Neutron Star in binaries: a<0.4 (Chakrabarty, arXiv:0809.4031)
  - Fastest observed pulsar J0737–3039A: a=0.05 (Burgay et al. arXiv:astro-ph/0405194)
- Fiducial BHNS: 10 $M_\odot$ - 1.4 $M_\odot$, with black hole spin: 0<a<1

Spin and Sky Localisation

- 3-detector network
- From timing alone, 2 blobs



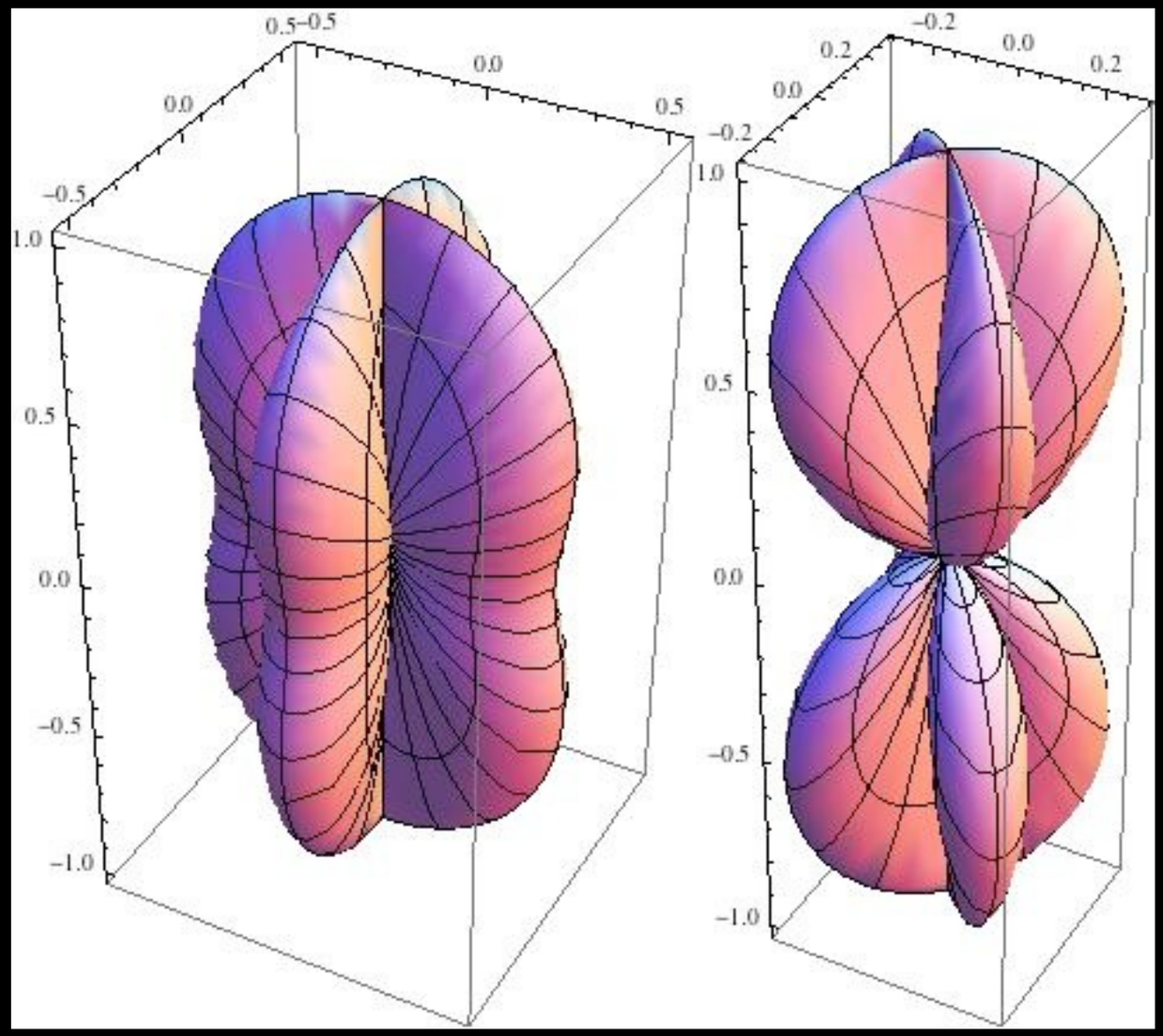
HI

LI

VI

Spin and Sky Localisation

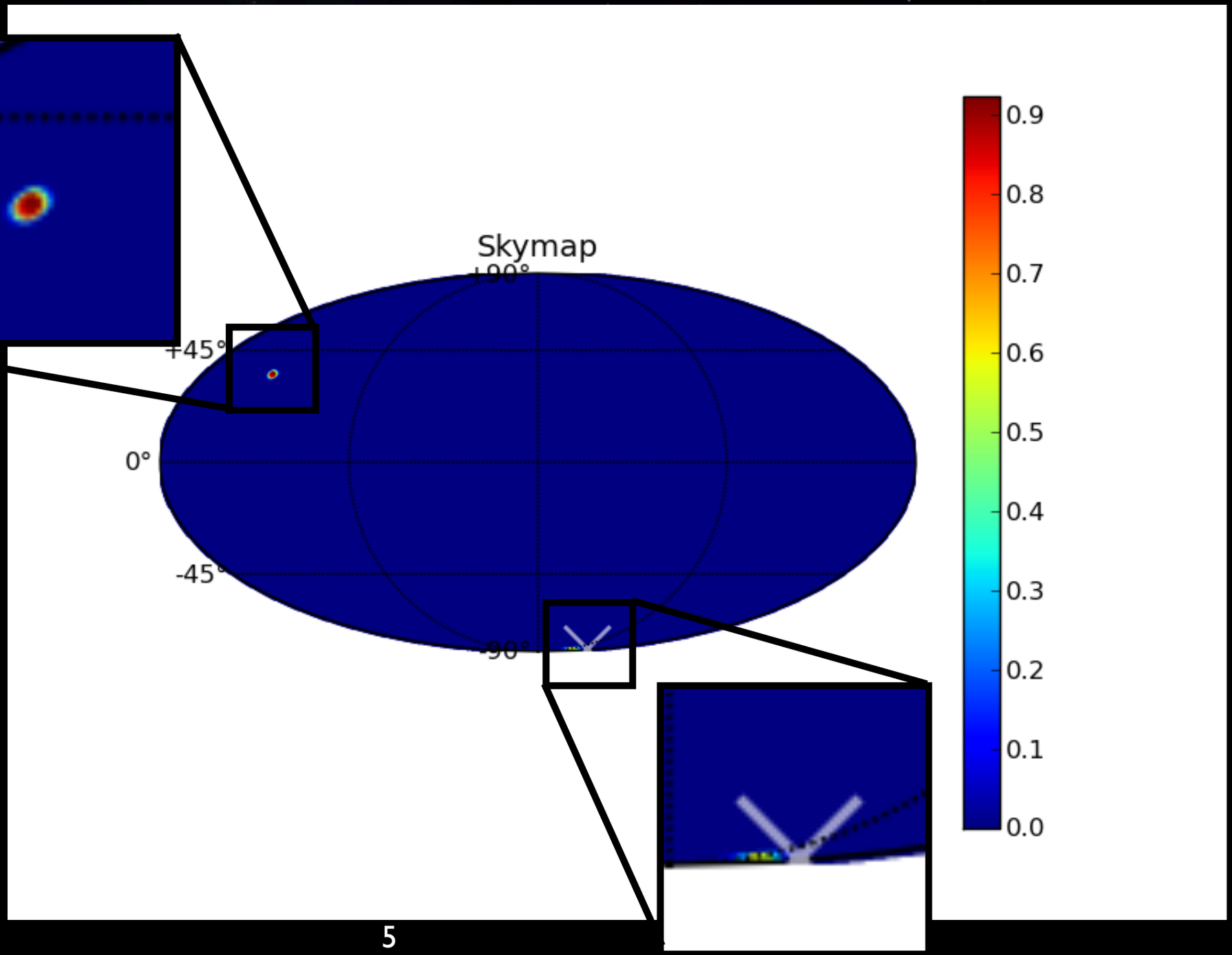
- Projection effects
- GW Interferometry-based detectors:
  - No pointing instruments
  - But not uniform on the sky in sensitivity



Sensitivity patterns

Illustration

- SNR=50
- a_1=0.7, a_2=0.1
- **L.S**$_1$=64°, **L.S**$_2$=90°



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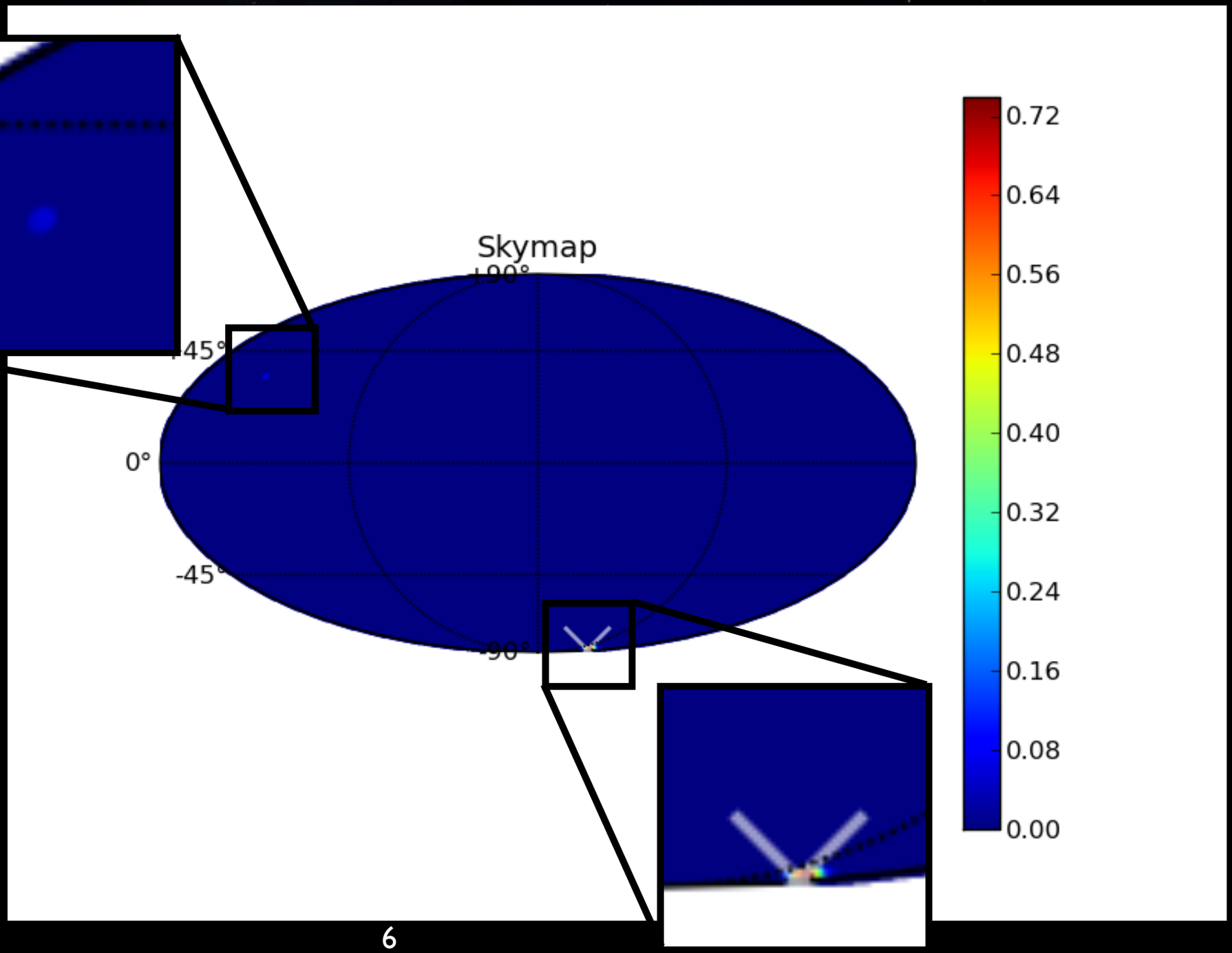
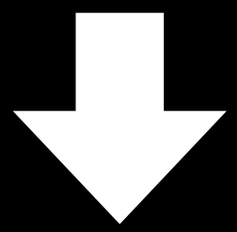


Compact binary coalescence

- Data analysis:

Detection (matched filtering)



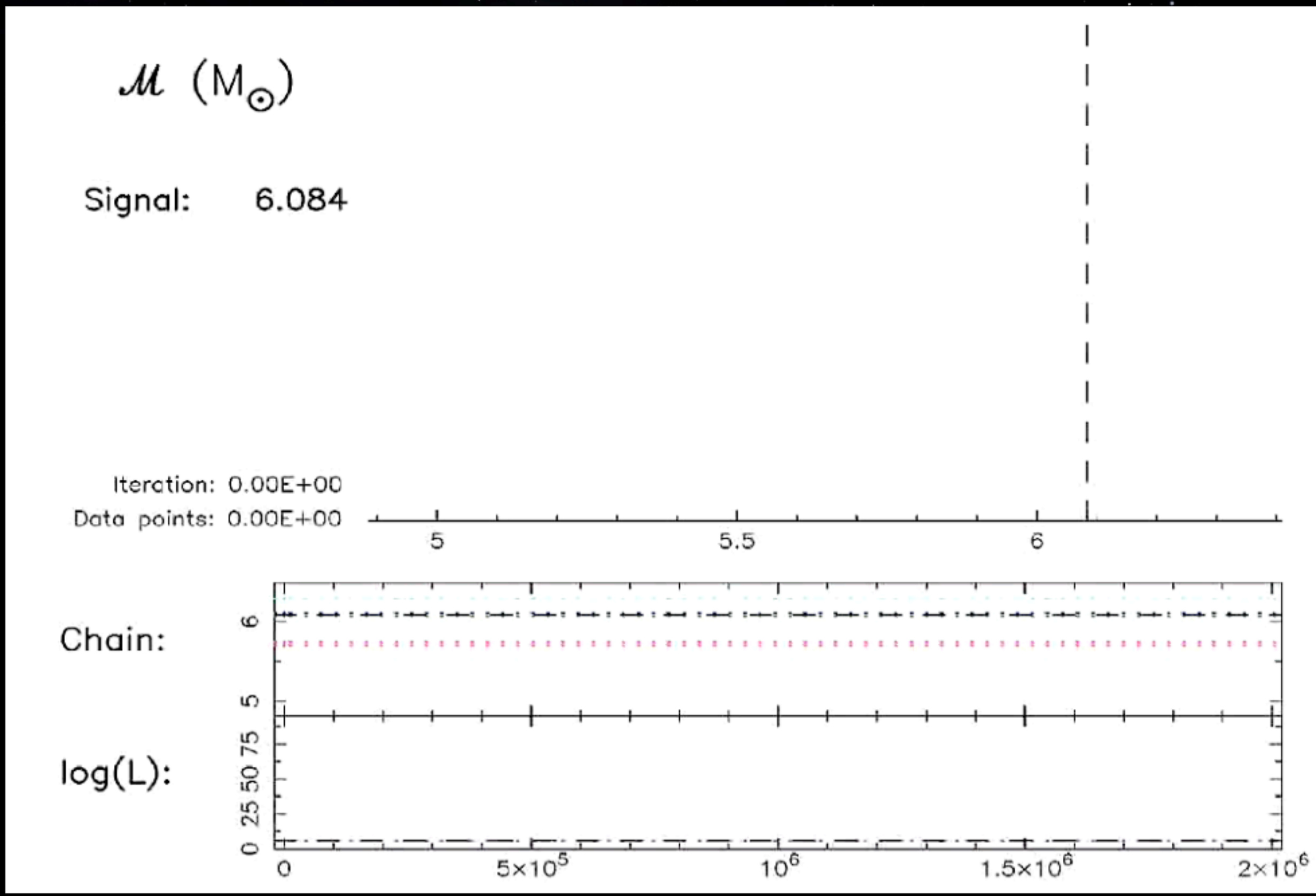
Coherent extraction of astrophysical properties

Bayesian Inference

- Bayes Theorem: $$posterior = \frac{prior \ * likelihood}{evidence}$$

- Parameter Estimation: $$p(\vec{\lambda}|\vec{x}, M) = \frac{p(\vec{\lambda}|M)\, p(\vec{x}|\vec{\lambda}, M)}{p(\vec{x}|M)}$$

- Model selection: $$p(M|\vec{x}) = \frac{p(M)\, p(\vec{x}|M)}{p(\vec{x})}$$

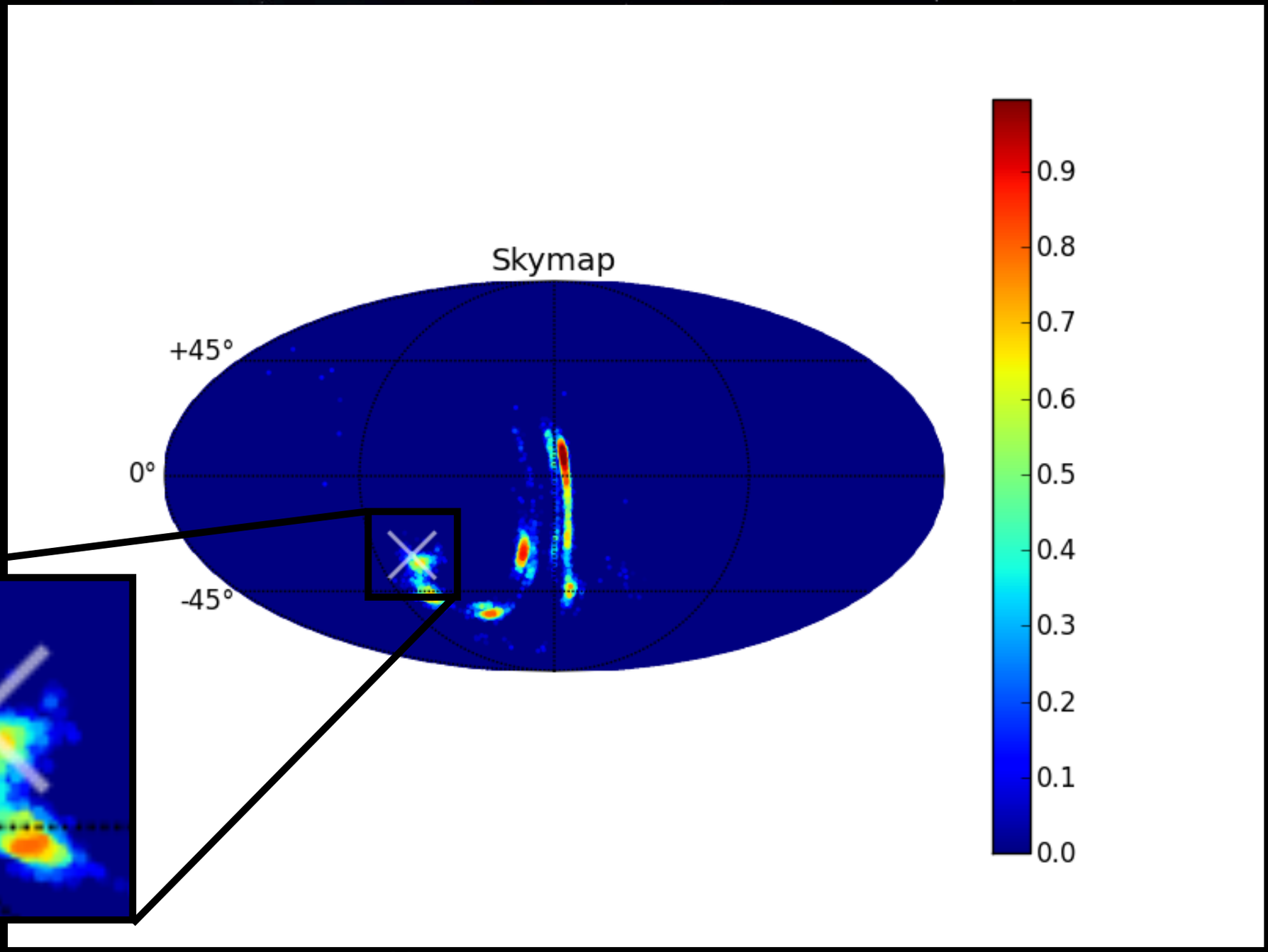

$\mathcal{M}$ ($M_\odot$)
Signal: 6.084
Iteration: 0.00E+00
Data points: 0.00E+00
5
5.5
6
Chain:
log(L):
0 25 50 75
5
6
0
5×10^5
10^6
1.5×10^6
2×10^6

Simulation

- BNS 1.4 $M_\odot$ - 1.4 $M_\odot$ with uniform spins: $0 \leq a \leq 0.7$
- NSBH 1.4 $M_\odot$ - 10 $M_\odot$
  - Neutron star spin: $0 \leq a \leq 0.7$
  - Black hole spin: $0 \leq a \leq 1$
- Uniform distribution in orientation, sky position, volume
- Network SNR threshold: 15
- Early advanced detector Network (H1, L1, V1)

Illustration

- SNR=15
- a_1=0.4, a_2=0.5
- **L.S**$_1$=67°, **L.S**$_2$=76°
- Low H1 SNR (~5)



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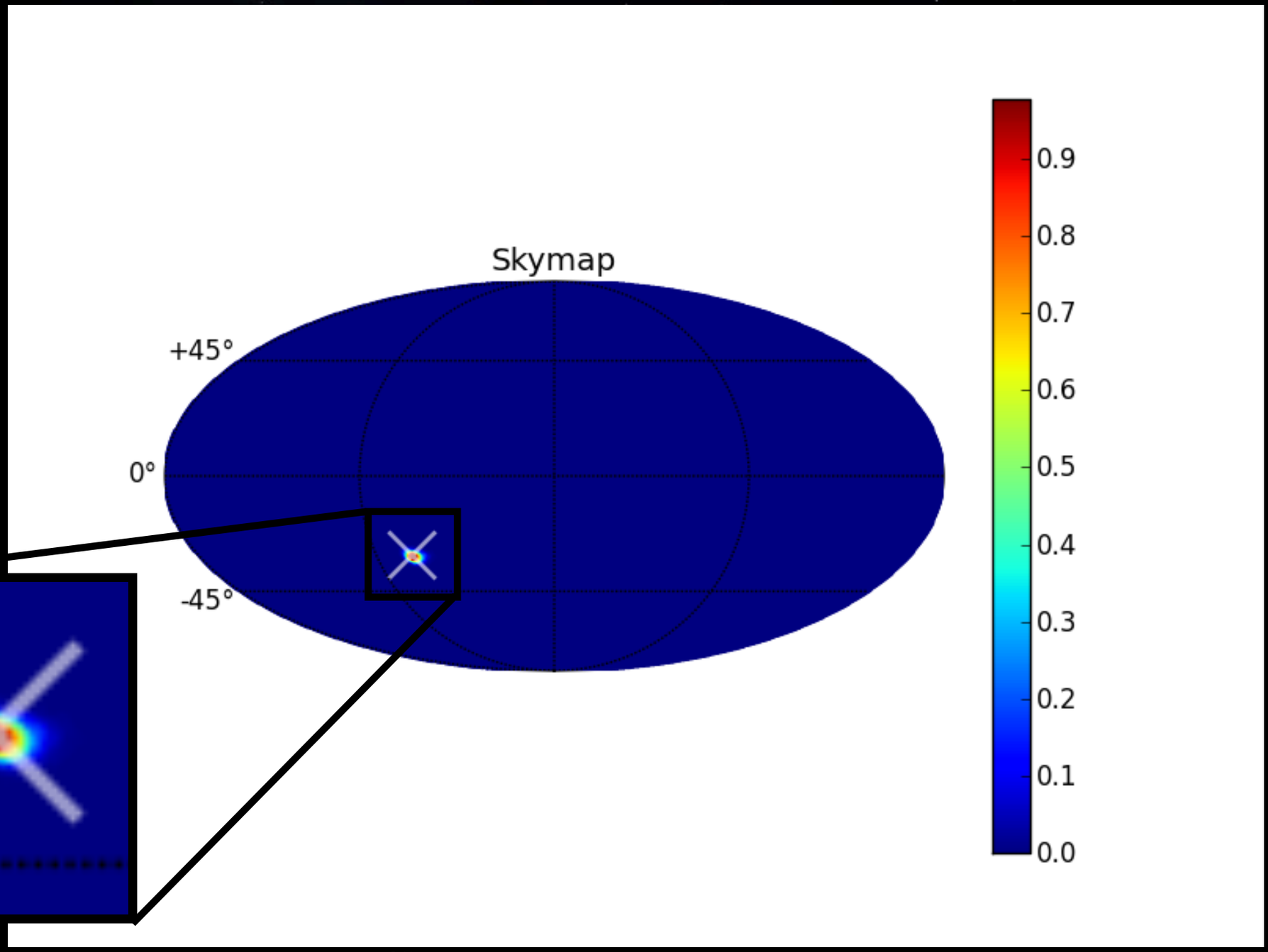

In numbers

- Loss of ~40% of the signals (at the 90% confidence level)
  - One low SNR in the network (big sky area)
  - Wrong mode preferred (similar sky area)
- Spin aligned templates improve over non-spinning by:
  - Loss of ~20% for BNS
  - Loss of ~10% for NSBH

NUMBERS DEPEND ON THE DETAILS OF THE SIMULATION

Questions

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